4329

Effect of Altered Dextrose Equivalent on Nutritional Quality and Flavor of Whey Soy Drink Mix

ABSTRACT

Substitution of either 26 to 29 dextrose equivalent corn syrup solids or 9 to 12 dextrose equivalent dextrin for 40 to 44 dextrose equivalent corn syrup solids in a whey soy drink mix formulation did not decrease the standardized protein effiency ratio, net protein ratio, apparent dry matter digestibility, or apparent nitrogen digestibility of the beverage powder after 12 mo-storage at either 25 C or 37 C. After 12 mo-storage at 37 C, the 9 to 12 powder, the 26 to 29 powder, and the 40 to 44 control, respectively, showed protein efficiency ratios, 2.07 ± .05, 2.15 ± .04, and 2.12 ± .04; net protein ratios, 3.32 ± .06, 3.41 ± .05, and 3.36 ± .06; digestibility of dry matter, 92.3% ± .63, 93.3% ± .13, and 93.7% ± .29; digestibility of nitrogen 81.6% ± .77, 82.5% ± .69, and 84.2% ± .30. No lysine destruction occurred in any of the samples stored at 37 C, and 93 to 94% of the lysine was measured as chemically available after 12 mo. Vitamin A decreased 28 to 36% in these samples over storage, but Vitamin C showed little change.

Using a ranking test, judges rated the 40 to 44 control sweeter than both the 26 to 29 and 9 to 12 products. However, when these products were scored against a hidden 40 to 44 control, only the 9 to 12 product consistently received a lower flavor score over storage.

Although substitution of the 26 to 29 corn syrup solids or the 9 to 12 dextrin did not reduce protein quality and digestibility over the time studied, only the former provided the flavor qualities required for whey soy drink.

INTRODUCTION

Declining food reserves and increasing food prices coupled with stringent antipollution regulations have brought about the development of new food products incorporating large quantities of cheese whey. An example of such a product is whey soy drink mix (WSDM), which was created as a nonfat dry milk replacer in international child-feeding programs when nonfat dry milk was in short supply and priced out of reach for overseas distribution (3).

Under commodity specifications (27), WSDM must contain 9% corn syrup solids with a dextrose equivalent (DE) of 40 to 44. When sucrose prices rose to unprecedented highs in late 1974 (28), supplies of corn syrup solids, particularly 42 DE, became scarce, and manufacturers had difficulty in supplying WSDM priced sufficiently low to meet the needs of the U.S. Food-for-Peace program. Therefore, product supply might be maintained at a reasonable price by utilization of different dextrose equivalent corn sweeteners in the WSDM formulation if the substitution could be made without loss of product quality.

Two criteria were selected that any WSDM prepared with an alternate corn sweetener ingredient would have to meet. First, as WSDM was designed specifically as a dietary supplement for preschool children receiving inadequate protein (14), the substitution could cause no changes in protein nutritional quality as measured by protein efficiency ratio (PER) and nitrogen digestibility, either initially or after prolonged storage. In addition, as WSDM underwent extensive consumer acceptance trials before being adopted into Title II food distribution programs (24), a substitute corn sweetener could cause no deleterious flavor changes

Received January 30, 1978.

[1] Nutrition Institute, Agricultural Research Center, U.S. Department of Agriculture, Beltsville, MD 20705.

[2] Agricultural Research Service, U.S. Department of Agriculture.

in the product. The work reported here describes the effect of the substitution of corn sweeteners of DE lower than 42 on some flavor and nutritional quality characteristics of WSDM during storage.

MATERIALS AND METHODS

Three samples of WSDM were prepared commercially as described (14). Frodex-24[3] corn syrup solids (26 to 29 DE) or Maltrin-10 dextrin (9 to 12 DE) were substituted in the formulation (Table 1). A sample prepared with Frodex-42 corn syrup solids (40 to 44 DE) served as a control. All samples met commodity specifications for proximate composition and properties relating to reconstitutability (27). For biological evaluation studies, 2.7-kg samples of the three powders were nitrogen packed in No. 10 cans and stored at −18 C for controls. Additional samples were air-packed in No. 10 cans and stored in constant temperature incubators set at 25 and 37 C. Packaging in this manner eliminated moisture uptake as a factor over storage. Samples to be examined were withdrawn from 37 C storage after 3, 6, and 12 mo and from 25 C storage after 6 and 12 mo. The controls were evaluated initially and after 12 mo of storage.

Male albino rats of the Sprague Dawley strain were obtained commercially and divided into treatment groups of 10 to 12 per group except for 6 per group for a nitrogen-free diet. The animals were housed individually and fed a stock diet for 2 to 3 days after arrival before being assigned to the experimental diets. Average initial weights varied from 59 to 63 g. Food and water were supplied ad libitum. The animal room was maintained at 25 C and 50% RH (relative humidity); it was also controlled with 12-h periods of light and darkness.

The effects of the various treatments on protein quality and on apparent digestibility of dry matter and nitrogen were studied. Protein quality was mesured as PER as specified by the AOAC (4) and net protein ratio (NPR) by the

TABLE 1. Formulation of whey soy drink mix.

Ingredient	%
Sweet cheese whey solids	41.3
Defatted soy flour	29.7
Soybean oil	19.0
Corn sweetener	9.0
Vitamins and minerals	1.0

method of Bender and Doell (5). Amounts of the WSDM samples and ANRC casein to furnish 10% protein (total nitrogen × 6.25) were incorporated into diets (Table 2) and fed for 28 days. Because the soybean oil in the WSDM samples supplied 9.4% fat in the diet, 9.4% vegetable oil was added to the ANRC-casein control diet and to the nitrogen-free diet. An appropriate amount of USP-salt mixture XVIII was added to the diets containing WSDM to bring the total mineral content to 5%; 5% of the salt mixture was added to the casein control and nitrogen-free diets. A casein control group and a group receiving the nitrogen-free diet were fed at every time interval along with the groups receiving diets containing WSDM. The same lot of casein was used throughout the study.

Weight gains and food intakes were determined weekly. Scattered food was recovered thoroughly. During wk 2, feces were collected from all rats fed the initial samples; during subsequent evaluations of effects in storage, feces were collected from only six animals in each group. Feces were frozen until the end of the collection period, dried under infrared lamps, allowed to equilibrate to ambient moisture, weighed, and ground.

Nitrogen was determined on all mixed diets and on all fecal samples by a macro Kjeldahl procedure (4). Nitrogen analyses were used to determine protein intake (total nitrogen × 6.25) and for calculating PER, ND, and NPR. Statistical analyses for significance were standard procedures (25). Concentrations of total lysine and lysine chemically available for reaction with 1-fluoro-2,4-dinitrobenzene[4] were measured in the control and experimental samples initially and after storage at 37 C for 6 and 12 mo. A control stored at −18 C for the same times was also examined. Total lysine in the samples was determined with a Beckman Model 120C amino acid analyzer according to the

[3] Reference to brand or firm name does not constitute endorsement by the U.S. Department of Agriculture over others of a similar nature not mentioned.

[4] 1-Fluoro-2,4-dinitrobenzene is a skin vesicant and may cause allergic reactions in some individuals.

TABLE 2. Formulation of basal diets used in feeding studies.

Component	Diet: Casein control	Nitrogen free	Average WSDM
		(%)	
ANRC casein	11.3	...	...
WSDM	...	...	47.6
Salt mix XVIII	5.0	5.0	2.0
Vegetable oil[a]	9.4	9.4	...
Vitamins[b]	1.0	1.0	1.0
Non nutritive[c] fiber	1.0	1.0	1.0
Cornstarch	72.3	83.6	48.4

[a]Wesson oil.

[b]General Biochemicals, Chagrin Falls, OH.

[c]Teklad Mills, Madison, WI.

method of Spackman et al. (26). Available lysine was measured as the difference between blocked and total lysine by the procedure of Couch (7). Total lysine was reported as the average of duplicate analyses on samples hydrolyzed for 24 and 48 h; available lysine was measured in duplicate.

Vitamins A and C were measured in all stored samples submitted for biological evaluation. Vitamin A was determined by an AOAC procedure (4). The spectrophotometric method of Loeffler and Ponting (18) was used for the determination of ascorbic acid. The samples were extracted with a solution of metaphosphoric acid, acetic acid, and methanol (8). The methanol eliminated turbidity due to lipid in the samples.

For other storage stability studies, samples of WSDM containing Frodex-42 were nitrogen packed in No. 211 × 414 cans and stored at −18 C as controls. Additional samples of the three powders were air-packed in No. 211 × 414 cans and stored at 25 and 37 C.

All taste panels were trained dairy products judges selected for sensory acuity (17) who had received additional training in recognition of beany, rancid, and reverted soybean oil flavors. Panels averaged 14 members; one panel had the minimum number of 11 judges. For organoleptic evaluation, samples were reconstituted with distilled water to 15% total solids just prior to being tasted. Initially, triangle tests and ranking tests for flavor and texture of the experimental samples were according to standard procedures (1). Samples also were rated for preference in a limited test by a 15-member panel using the 9-point hedonic scale of Peryam and Pilgrim (22).

For monitoring of flavor changes during storage, samples were withdrawn after 3, 6, 9, and 12 mo. The reconstituted control sample that had been stored at −18 C was divided into two parts. One part was presented to the judges as a known control that had been given a score of 7 on a 10-point scoring system. In this system 1 equaled strong undesirable flavor and 10 equaled bland flavor; the minimum acceptable flavor equaled 6. The other part of the control was coded and given to the judges as a hidden control among the air-packed samples which had been stored at elevated temperatures. The score received by the hidden control served as the standard against which scores given to the other samples were compared. Separate panels were conducted for the products stored at 25 C and those stored at 37 C. Statistical evaluations for significance were made after completion of each taste panel by analysis of variance and Duncan's Multiple Range Test (1).

RESULTS

It was thought that WSDM prepared with Frodex-42 or Maltrin-10 might be more difficult to digest than WSDM containing Frodex-42 because of the higher concentration of long-chain polysaccharides contributed by the substitute corn sweeteners (6). Lack of digestibil-

TABLE 3. Percentage apparent dry matter and nitrogen digestibility at different storage times and temperatures.

Storage time (mo)	Frodex-42		Frodex-24		Maltrin-10	
	DM[a]	ND[b]	DM[a]	ND[b]	DM[a]	ND[b]
Initial[c]	93.7 .16[e]	84.3 .46	93.3 .17	83.9 .37	93.6 .17	84.8 .42
25 C, air pack						
6[d]	91.9 .27	79.9 .65	93.4 .35	84.3 .50	93.0 .40	82.9 .75
12[d]	92.2 .26	80.5 .28	93.0 .23	82.1 .68	92.9 .19	83.4 .59
37 C, air pack						
3[d]	93.0 .22	83.0 .73	93.2 .18	83.8 .58	92.9 .44	83.0 .82
6[d]	93.3 .23	83.3 .86	93.1 .16	82.4 1.16	92.1 .23	82.9 .60
12[d]	93.7 .29	84.2 .30	93.3 .13	82.5 .69	92.3 .63	81.6 .77
−18 C, N_2 pack						
12[d]	93.0 .18	82.1 .78	93.0 .23	82.4 .50	93.1 .15	82.3 .28

[a]Apparent dry matter digestibility = (food intake − fecal wt) × 100/food intake.

[b]Apparent nitrogen digestibility = (nitrogen intake − fecal nitrogen) × 100/nitrogen intake.

[c]12 animals/group.

[d]6 animals/group.

[e]Mean ± SE.

ity could affect growth and interfere with the determination of protein quality as measured by PER and NPR. Therefore, the apparent dry matter digestibility and the apparent nitrogen digestibility of the WSDM samples were determined over the storage period (Table 3). No effect of formulation, storage time, or temperature on these two parameters was observed.

Average weight gains of the groups of rats fed the 21 WSDM samples varied from a low of 3.4 (Frodex-24, stored 3 mo at 37 C) to a high of 4.5 g/day (Frodex-24, stored 12 mo at 37 C) and appeared unrelated to the sample treatment (Table 4). Feed efficiencies for the groups of animals fed the WSDM samples showed little variation, ranging from .29 to .32 g/day. Although data are not shown, average daily weight gains of the four casein-control groups varied from 3.8 (control for 3 mo) to 5.4 g/day (control for 12 mo); the average feed efficiencies of animals fed the casein-control diets ranged from .32 (control for 6 mo) to .37 g/day (control for 12 mo).

Commodity specifications (28) require WSDM to have a minimum PER of 1.9 and preferably higher. All standardized PER values for the 21 samples of WSDM exceeded 2.0, even after storage at 37 C for 1 yr (Table 5). There were no significant differences in standardized PER values between initial samples of WSDM and those stored for 12 mo at 25 and 37 C. Standardized values for the samples stored for 6 mo at 25 and 37 C were greater than either the initial sample values or those stored for 12 mo, but this was attributed to the PER value for the 6 mo casein-control group being significantly lower than the other casein control values. This was true even though diets throughout the study were formulated with the same lot of casein. The PER values for the 21 WSDM samples varied less over storage than did those of the casein control.

A common criticism of PER as a measure of protein quality is that dietary protein required for maintenance of the animal is not included (11, 12, 20). Accordingly, NPR's were measured (Table 6). The data show no effects attributable to formulation, storage time, or temperature of storage.

The WSDM was substituted into the Food-for-Peace program as a replacer for nonfat dry milk. Nutritional quality of WSDM was related to that of fresh nonfat dry milk by comparing the calculated relative nutritive values of the WSDM samples over storage with those of a sample of nonfat dry milk which was fed at the same time as the initial WSDM samples (Table

TABLE 4. Variation of average weight gain and feed efficiencies with storage time and temperature.

Storage time (mo)	Frodex-42		Frodex-24		Maltrin-10	
	WG[a]	FE[b]	WG[a]	FE[b]	WG[a]	FE[b]
Initial	4.3 .17[c]	.31	4.4 .20	.31	4.4 .13	.30
25 C, air pack						
6	3.8 .12	.29	3.9 .14	.29	4.1 .24	.31
12	4.4 .19	.31	4.2 .17	.31	4.3 .17	.31
37 C, air pack						
3	4.0 .29	.31	3.4 .25	.30	3.9 .16	.31
6	3.8 .13	.30	4.0 .18	.29	3.7 .16	.29
12	4.4 .12[d]	.31	4.5 .18	.30	4.1 .19	.29
−18 C N_2 pack						
12	4.3 .15	.12	4.3 .17	.30	4.7 .19	.32

[a]Average weight gain = g/rat per day.

[b]Feed efficiency = g weight gain/g feed consumed.

[c]Mean ± SE.

[d]9 animals/group.

TABLE 5. Variation of observed and standardized protein efficiency ratios with storage time and temperature.

Storage time (mo)	Frodex-42		Frodex-24		Maltrin-10		Casein control not stored	
	Observed	Stdized.	Observed	Stdized.	Observed	Stdized.	Observed	Stdized.
Initial	3.00 .05[a]	2.16 .04	3.03 .06	2.18 .04	2.96 .05	2.13 .04	3.47 .09	2.50 .06
25 C, air pack								
6	2.81 .07	2.29 .06	2.82 .09	2.30 .07	3.02 .06	2.46 .05		
12	2.97 .06	2.15 .05	2.93 .07	2.12 .05	3.08 .05	2.23 .03		
37 C, air pack								
3	2.96 .10	2.25 .08	2.92 .10	2.22 .08	3.07 .05	2.33 .04	3.29 .10	2.50 .08
6	2.92 .07	2.38 .06	2.89 .07	2.35 .06	2.83 .06	2.30 .05	3.07 .04[c]	2.50 .03
12	2.93 .06[b]	2.12 .04	2.97 .06	2.15 .04	2.85 .07	2.07 .05	3.45 .05	2.50 .04
−18 C, N_2 pack								
12	3.05 .06	2.21 .05	2.94 .07	2.13 .05	3.11 .10	2.25 .07		

[a]Mean ± SE.

[b]9 animals/group.

[c]Significantly different from other values at 1%.

TABLE 6. Variation of net protein ratio with storage time and temperature.[a]

Storage time (mo)	Frodex-42 −18 C N_2 pack	Frodex-42 25 C Air pack	Frodex-42 37 C Air pack	Frodex-24 −18 C N_2 pack	Frodex-24 25 C Air pack	Frodex-24 37 C Air pack	Maltrin-10 −18 C N_2 pack	Maltrin-10 25 C Air pack	Maltrin-10 37 C Air pack	Casein control
Initial	3.46 .05[b]	. . .	. . .	3.48 .05	. . .	. . .	3.41 .05	. . .	. . .	3.96 .05
3	. . .	. . .	3.46 .08	. . .	. . .	3.50 .09	. . .	. . .	3.59 .05	3.86 .10
6	. . .	3.29 .08	3.42 .08	. . .	3.30 .09	3.37 .07	. . .	3.52 .06	3.35 .06	3.60 .06
12	3.53 .06	3.42 .06	3.36 .06[c]	3.40 .07	3.40 .07	3.41 .05	3.56 .09	3.55 .05	3.32 .06	3.87 .05

[a]Net protein ratio = (weight loss of group on nitrogen free diet + weight gain)/(protein intake).

[b]Mean ± SE.

[c]9 animals/group.

7). Calculations used the NPR's (Table 6); the NPR of the sample of nonfat dry milk was 4.13 ± .05. Over storage, relative nutritive value with respect to nonfat dry milk averaged 83% for the samples containing Frodex-42 and Frodex-24 and 84% for the sample containing Maltrin-10. Although results fluctuated, those samples stored at 37 C seemed to show a slight decrease in nutritive value with time.

For the amino acid requirements for young children (15), lysine was the first limiting amino acid in WSDM. Because lysine inactivation and destruction could be responsible for the seeming decrease in relative nutritive value, total and available lysine were measured in the WSDM samples stored at 37 C for 6 and 12 mo (Table 8). The content of total and available lysine showed little change over storage, and the lysine percentage available for nutrition as measured chemically was high.

Vitamins and minerals are added to WSDM to increase nutritional value before it is shipped overseas. To gain some information about vitamin deterioration during storage, concentrations of Vitamins A and C were measured in all stored samples. Vitamin A (Table 9A) decreased slightly in samples stored at 25 C, with the greatest decrease in the final 6 mo of storage; at 37 C, the decrease ranged from 28 to

TABLE 7. Variation of relative nutritive value[a] of whey soy drink mix with storage time and temperature.

Storage time (mo) and temperature	Frodex-42	Frodex-24	Maltrin-10
		(%)	
Initial	84	84	83
25 C, air pack			
6	80	80	85
12	83	82	86
37 C, air pack			
3	84	85	87
6	83	82	81
12	81	83	80
−18 C, N_2 pack			
12	85	82	86

[a]Nonfat dry milk = 100.

TABLE 8. Variation in total and available lysine with time of whey soy drink mix stored at 37 C.

Storage time (mo)	Lysine/sample (g/100 g) Frodex-42 Total	Frodex-42 Avail.	Frodex-42 % Avail.	Frodex-24 Total	Frodex-24 Avail.	Frodex-24 % Avail.	Maltrin-10 Total	Maltrin-10 Avail.	Maltrin-10 % Avail.
Initial	1.43	1.30	91.0	1.43	1.34	93.7	1.49	1.41	94.6
6	1.44	1.35	93.8	1.42	1.31	92.2	1.40	1.30	92.9
12	1.46	1.36	93.2	1.47	1.39	94.6	1.44	1.36	94.4
−18 C, N_2 pack									
12	1.44	1.34	93.1	...	...	...	...	...	...

TABLE 9. Vitamin stability as a function of storage time and temperature.

Storage time (mo)	Frodex-42 −18 C N_2 pack	Frodex-42 25 C Air pack	Frodex-42 37 C Air pack	Frodex-24 −18 C N_2 pack	Frodex-24 25 C Air pack	Frodex-24 37 C Air pack	Maltrin-10 −18 C N_2 pack	Maltrin-10 25 C Air pack	Maltrin-10 37 C Air pack
Part A. USP units Vitamin A/100 g sample									
Initial	1975	...	...	1960	...	...	1722	...	...
3	...	1728	1620	...	1636	1558	...	1768	1649
6	...	1825	1578	...	1766	1449	...	1818	1618
12	1790	1581	1420	1990	1562	1245	1770	1680	1204
Part B. mg Vitamin C/100 g sample									
Initial	48.0	...	...	48.7	...	...	46.7	...	...
3	...	43.0	41.3	...	44.8	45.8	...	42.1	43.7
6	...	39.4	40.5	...	46.4	42.1	...	45.5	42.3
12	47.6	47.8	47.7	47.2	45.8	47.0	47.1	45.2	43.4

36% from the initial values. Vitamin A decreased 10% in the Frodex-42-containing product stored under nitrogen at −18 C for 12 mo but did not change in the other samples stored under similar conditions. In contrast to Vitamin A, Vitamin C showed little change in concentration at any storage temperature during storage (Table 9B).

Distribution of food of the best nutritional quality is useless if the intended recipient will not eat it because the flavor is unacceptable. Therefore, extensive organoleptic evaluations were conducted on the WSDM samples containing Frodex-24 or Maltrin-10 to determine if the substitute corn sweeteners decreased flavor acceptability.

Initial taste panel results were variable. Triangle tests for flavor differences showed that trained judges were unable to distinguish between the Frodex-42 control and either of the other samples. However, when asked to rank the samples for sweetness, they ranked the control significantly sweeter than either of the other samples. They found no significant differences in texture by either of the above tests.

When rated by a consumer preference test, the Maltrin-10-containing sample was significantly less well-liked than the Frodex-24-containing sample but not the control. There was no significant difference in flavor between the control and the Frodex-24-containing sample.

Variations in the average flavor scores of the three WSDM samples with storage time and temperature were evaluated (Table 10). The sample containing Maltrin-10 was rated significantly lower at 99% confidence than the hidden control initially and at 95% confidence after 6 and 12 mo of storage at 37 C. After 12-mo storage at 25 C, all three samples were rated significantly lower than the hidden control; the sample containing Maltrin-10 was significantly lower at 99% confidence.

DISCUSSION

The WSDM must be able to maintain good nutritional quality during prolonged storage under the adverse conditions in many tropical countries if it is to be an acceptable milk substitute in Title II food donation programs. In the presence of reducing sugars such as glucose and lactose, heat and moisture cause severe deterioration in the nutritive value of the pro-

TABLE 10. Variation of average flavor scores with storage time and temperature.

Storage time (mo)	Hidden control Frodex-42 −18 C, N_2 pack	25 C, Air pack			Hidden control Frodex-24 −18 C, N_2 pack	37 C, Air pack		
		Frodex-42	Frodex-24	Maltrin-10		Frodex-42	Frodex-24	Maltrin-10
Initial	7.00	7.13	6.60	6.06**	...	...	...	...
3	6.53	7.00	6.50	5.73*	6.91	6.75	6.91	6.58
6	6.63	6.63	6.63	5.95	6.72	6.63	6.68	5.77*
9	6.77	6.55	6.66	6.33	6.92	6.57	6.69	6.38
12	7.07	6.42*	6.46*	6.03**	6.73	6.56	6.70	5.80*

*Different from the hidden control at 5%.

**Different from the hidden control at 1%.

teins of nonfat dry milk during storage, mainly through inactivation of lysine, an animo acid essential for growth (13, 19, 21, 29); therefore, we decided to evaluate only WSDM samples containing corn sweeteners of DE lower than 42 under storage conditions where moisture uptake would not be a factor affecting quality. Lowering the DE not only lowered the concentration of reducing sugars free to react with lysine but also reduced product hygroscopicity during processing (9).

During 12 mo of storage at 25 and 37 C, no protein nutritional damage occurred in any of the samples as measured by digestibility, PER, and NPR. The significantly greater standardized PER values for all samples after 6 mo of storage seemingly result from the abnormally low casein PER value used to derive the results. Therefore, the higher standardized PER values for the WSDM samples stored for 6 mo should be viewed as an example of the variability in the PER method, even when the observed values are "corrected" to a value of 2.50 for the casein control groups (11, 16).

The apparent slight decline in relative nutritive value of samples of WSDM stored at 37 C (compared to that of fresh nonfat dry milk) was not meaningful because the NPR values used to calculate the relative nutritive value showed no significant changes with storage time and temperature, and there was no evidence of lysine destruction in those samples stored at 37 C.

Fortification with Vitamin A of all nonfat dry milk to be used in food donation programs has been recommended by the Protein Calorie Advisory Group of the United Nations System. Vitamin A deficiency mostly affects young children, and the xerophthalmia and blindness it leads to are serious public health problems with considerable socio-economic significance in many developing countries (23). Therefore, Vitamin A stability was monitored in the stored WSDM samples in the feeding studies. Because results of the Vitamin A determinations were so variable, it was difficult to relate change in the WSDM formulation to Vitamin A deterioration during storage. Data for the samples stored at 37 C for 12 mo suggest that the DE of the corn sweeteners had no effect on Vitamin A destruction. The maximum Vitamin A deterioration equaled the 30% overages manufacturers may add under present commodity specifications (27); therefore, if overages are added, even after 12 mo storage at 37 C, WSDM still would supply the bulk of a child's daily requirement (2) for Vitamin A.

Although Vitamin C is destroyed readily by heat in the presence of oxygen (10), little change was observed in Vitamin C content in any WSDM sample over storage. Some B vitamins are also heat labile (10), but their concentrations in the WSDM samples over storage were not investigated because of difficult and time consuming assays.

The DE of the corn sweetener in the WSDM formulation affected the flavor of the reconstituted beverage. Examination of the average flavor scores received by the WSDM samples showed that the product containing Maltrin-10 consistently received lower scores, regardless of storage time and temperature. Scores given to the hidden controls for both sets of stored samples varied considerably and affected the statistical significance of the results, even though judges were the same. This suggests that judges had difficulty in distinguishing flavor differences among the hidden control and the air-packed samples containing Frodex-42 or Frodex-24, even though they ranked the control sample significantly sweeter than both other samples in the initial flavor evaluation studies.

Rancid off-flavor development was not a factor. Measured peroxide values (meq O_2/kg fat) never exceeded 2.5 in any sample over storage (data not shown).

Although there were no nutritional differences among any of the samples that could be attributed directly to the effect of the alternative corn sweetener in the WSDM formulation even after 12 mo storage at 37 C, Maltrin-10 was not an acceptable substitute for Frodex-42 because of reduced flavor acceptability. If protected from moisture uptake during storage, WSDM containing Frodex-24 or its equivalent can be expected to maintain protein quality and flavor acceptability equal to that of WSDM containing corn syrup solids equivalent to Frodex-42. Commodity specifications for WSDM will not be changed at present to allow the use of corn syrup solids of DE lower than 40 to 44. However, our work has shown that, in times of future shortages, consideration could be given to permitting the substitution of corn sweeteners of DE as low as 26 to 29 to maintain a constant product supply and meet Food-for-Peace commitments overseas.

ACKNOWLEDGMENTS

The authors express their sincere thanks to Ed Egermeier, Sanna Division, Beatrice Foods, for the samples.

REFERENCES

1 American Society for Testing and Materials. 1976. Page 22 *in* Manual on sensory testing methods. ASTM Special Technical Publication No. 434. Philadelphia, PA.

2 Anonymous. 1974. Page 129 *in* Recommended dietary allowances. 8th ed. National Research Council, National Academy of Sciences, Washington, DC.

3 Anonymous. 1974. Whey soy: The beverage made to order. Farm Index 13(3):9.

4 Association of Official Analytical Chemists. 1970. Official methods of analysis. 11th ed. Washington, DC.

5 Bender, A. E., and B. H. Doell. 1957. Biological evaluation of protein: a new aspect. Brit. J. Nutr. 11:140.

6 Corn Industries Research Foundation, Inc. 1965. Page 32 *in* Corn syrups and sugars. 3rd ed. Washington, DC.

7 Couch, J. R. 1975. Collaborative study of the determination of available lysine in proteins and feeds. JAOAC 58:599.

8 Egberg, D. C., P. A. Larson, and G. R. Honold. 1973. Automated determination of Vitamin C in some fortified foods. J. Sci. Food Agr. 24:789.

9 Egermeier, E. 1976. Personal communication.

10 Hartman, A. M., and L. P. Dryden. 1965. Page 16, 62 *in* Vitamins in milk and milk products. Amer. Dairy Sci. Ass., Champaign, IL.

11 Hegsted, D. M., and Y. Chang. 1965. Protein utilization in growing rats. I. Relative growth index as a bioassay procedure. J. Nutr. 85:159.

12 Hegsted, D. M., and J. Worcester. 1947. A study of the relation between protein efficiency and gain in weight on diets of constant protein content. J. Nutr. 33:685.

13 Henry, K. M., S. K. Kon, C. H. Lea, and J. C. D. White. 1948. Deterioration on storage of dried skim milk. J. Dairy Res. 15:292.

14 Holsinger, V. H., C. S. Sutton, L. F. Edmondson, P. R. Crowley, B. L. Berntson, and M. J. Pallansch. 1977. Production and properties of a nutritious beverage base from soy products and cheese whey. Page 25 *in* Proc. 4th Intern. Congr. of Food Sci. and Tech., Madrid, Spain. September 23–27, 1974. Vol. V., Instituto Nacional de Ciencia y Technologia de Alimentos, Madrid, Spain.

15 Holt, L. E., Jr., and S. E. Snyderman. 1965. Protein and amino acid requirements of infants and children. Nutr. Abstr. Rev. 35:1.

16 Hurt, H. D., R. H. Forsythe, and C. H. Krieger. 1975. Factors which influence the biological evaluation of protein quality by the protein efficiency ratio method. Page 87 *in* Protein nutritional quality of foods and feeds. Part 1. Mendel Friedman, ed. Marcel Dekker, Inc., New York, NY.

17 Liming, N. E. 1966. Consistency of a trained test panel. J. Dairy Sci. 49:628.

18 Loeffler, H. J., and J. D. Ponting. 1942. Ascorbic acid: Rapid determination in fresh, frozen, or dehydrated fruits and vegetables. Ind. Eng. Chem., Anal. Ed. 14:846.

19 Mauron, J., F. Mottu, E. Bujard, and R. H. Egli. 1955. The availability of lysine, methionine, and tryptophan in condensed milk and milk powder. In vitro digestion studies. Arch. Biochem. Biophys. 59:433.

20 Mitchell, H. H. 1944. Determination of the nutritive value of the proteins of food products. Ind. Eng. Chem., Anal. Ed. 16:696.

21 Patton, S. 1955. Browning and associated changes in milk and its products: A review. J. Dairy Sci. 38:457.

22 Peryam, D. R., and F. J. Pilgrim. 1957. Hedonic scale method of measuring food preferences. Food Technol. 11(9):Insert 9.

23 Protein Calorie Advisory Group of the United Nations System. 1976. Vitamin A enrichment of donated foods (with special reference to dry skim milk powder). PAG Bull. VI(4):1.

24 Rodier, W. I., III, W. C. Wetsel, H. L. Jacobs, R. C. Graeber, H. R. Moskowitz, T. J. E. Reed, and D. Waterman. 1973. The acceptability of whey-soy mix as a supplementary food for pre-school children in developing countries. Technical Rep. 74-20-PR. U. S. Army Natick Laboratories, Natick, MA.

25 Snedecor, G. W. 1959. Statistical methods. Iowa State College Press, Ames, IA.

26 Spackman, D. H., W. H. Stein, and S. Moore. 1958. Automatic recording apparatus for use in the chromatography of amino acids. Anal. Chem. 30:1190.

27 USDA, Agricultural Stabilization and Conservation Service. 1975. Purchase of whey soy drink mix for use in export programs. Announcement WD-3, July 25, Shawnee Mission, KS.

28 USDA, Economic Research Service. 1977. Page 47 *in* Sugar and sweetener report. SSR Vol. 2, No. 5, Washington, DC.

29 Williams, H. H., A. E. Harper, D. M. Hegsted, G. Arroyave, and L. E. Holt, Jr. 1974. Nitrogen and amino acid requirements. Page 23 *in* Improvement of protein nutrition. National Research Council, National Academy of Sciences, Washington, DC.